WEST AFRICAN CACAO RESEARCH INSTITUTE

# QUARTERLY PROGRESS REPORT

No. 35

TAFO, GOLD COAST.

COMMONWEALTH MYCOLOGICAL INSTITUTE
17 FEB 1955

# WEST AFRICAN CACAO RESEARCH INSTITUTE
# TAFO

## THIRTY-FIFTH QUARTERLY REPORT : JULY-SEPTEMBER, 1954

### SENIOR STAFF

| | |
|---|---|
| Director | ... J. West (retired 6/8/54) |
| Deputy Director | ... A. Pickles (Acting Director) |
| Maintenance Engineer | ... C. Alderson, D.S.O. |
| Secretary | ... G.H. Neal |

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### TAFO STATION

| | |
|---|---|
| Division of Entomology | ... J. Nicol (on leave)<br>... H.R. Mapother<br>... D.J. Taylor<br>... P.B. Cornwell<br>... F.E. Decker |
| Division of Pathology | ... W.T. Dale<br>... T.W. Tinsley<br>... A.L. Wharton<br>... G. Usher |
| Division of Botany | ... J.F. Archibald<br>... H.H. Rogers<br>... R. Knight<br>... A.D. McKelvie |
| Division of Soil Science and Chemistry | ... J.A.R. MacLean (resigned 8/8/54)<br>... S.N. Adams (returned 8th August) |
| Division of Agronomy | ... R.J. Benstead (on leave)<br>... R. Wickens |
| Station Manager | ... S.E.N. Kwafo |

### IBADAN SUB-STATION

| | |
|---|---|
| Entomologist | ... R.G. Donald |
| Pathologists | ... R.M. Lister (returned 5th August)<br>J.M. Thresh. |

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### STAFF MATTERS

The retirement of Mr. J. West, Director, became effective on the 6th August, 1954. Dr. J.A.R. MacLean, Chemist resigned with effect from the 8th August, 1954 to take up an appointment in the United Kingdom.

Dr. T.W. Tinsley represented the Institute at the Second International Virus Conference at Wageningen in June and at the Eighth International Botanical Congress at Paris in July. At two important soils conferences held in Leopoldville in August and September, the Institute was represented by Dr. S.N. Adams; these were the Soils Conference of the Committee for Technical Co-operation in Africa South of the Sahara and the Fifth International Congress of Soil Science.

The .../

The Acting Director, accompanied by Dr. Tinsley, paid a brief visit to England in August in order to attend a meeting at the Colonial Office of the Cocoa Research Sub-Committee of the Committee for Colonial Agricultural, Animal Health and Forestry Research. They also visited Bournville, Rothamsted Experimental Station and East Malling Research Station on business concerning the work of the Institute.

RESEARCH PROGRAMME

The Institute's Research Programme was presented in a new form for the current year and was prefaced by a statement of research policy. The programme itself gives greater details than previously of the work projected and most of the Items are concerned with long-range investigations. It is accordingly believed that, for some time to come, annual revision of the programme will be necessary, rather than the presentation of a new programme annually. Following the meeting of the Cocoa Research Sub-Committee, to which reference was made above, the Secretary of State gave his approval to the programme.

VISITORS

The number of visitors received by the Institute has increased greatly and to such an extent that to explain the work of the Institute to them without serious interruption of the work of the research staff has become a difficult problem. Visitors during the quarter under review have included members of the Imperial Defence College, a representative of the "Economist" Intelligence Unit, representatives of the chocolate industries of the United Kingdom, the United States of America and Germany, members of the staff of the Colonial Office and of the staffs of the Departments of Agriculture of the Gold Coast and Nigeria. Mr. James F. Gehr, of the United States Department of Agriculture visited the Institute in September. On the invitation of the Institute, Dr. E.W. Russell, Reader in Agriculture in the University of Oxford, spent some time at the Institute and made valuable comments and suggestions on soil problems and related matters.

COCOA FROM THE UPPER AMAZON INTRODUCTIONS

Perhaps the most important event of the quarter was the receipt of advice from the Cocoa, Chocolate and Confectionery Alliance Limited and, independently, from the Executive Committee of the Association of Cocoa and Chocolate Manufacturers of the United States of America, that certain of the high-yielding Upper Amazon selections produce cocoa of acceptable quality with the flavour range of West African Amelonado. The lists of selections approved by the two consumer organisations are not identical but the Departments of Agriculture concerned have been advised that planting material of the types common to both lists may now be distributed to farmers. These are: T60, 63, 65, 72, 73, 76, 79, 82, 85 and 87.

This long-awaited decision is most welcome, since it enables improved planting material to be issued to farmers in West Africa for the first time since the original introduction of cocoa.

DIVISION .../

## DIVISION OF AGRONOMY

### TAFO STATION

(a) Cacao Areas

Harvesting of the minor crop began in early July. The total number of pods produced from the Uniformity Trial Area of the Old Station showed that despite a promise of a very heavy mid-crop the increase was only 7.6% above the 16-year mean. Discards in the same area were at the satisfactorily low level of 7.1% compared with a 16-year mean of 16.4% leading together with the increased number of pods to a 22.1% increase in wet beans produced.

On the non-recorded cacao areas of the Station and Square Mile the percentage discards has been only 5.2%. These low discard percentages may be attributed to the regular weekly pickings and to the very low rainfall during July and August. (2.94 inches compared with 8.39 inches average over the previous 16 years).

(b) New Plantings

An area of 1.91 acres has been planted during the September rains. It is intended that this area, planted with Upper Amazon varieties at 6'x 6' as seed at stake, shall be used for a further establishment experiment. In conjunction with the Soil Chemist a set of experimental treatments has been agreed upon, designed to examine the effects of mineral fertilizers (nitrogen and phosphate) and dry season watering and mulching on plant survival and growth.

(c) Swollen Shoot Disease

The following table shows losses from Swollen Shoot disease and other causes on the Station and Square Mile :-

TABLE I

| Month | Old Station | | | Square Mile | | | |
|---|---|---|---|---|---|---|---|
| | Diseased | Other causes | Total | Diseased | Suspect | Contact | Total |
| July | 34 | 16 | 50 | 221 | 46 | 60 | 327 |
| August | 12 | 13 | 25 | 309 | 69 | 87 | 465 |
| September | 20 | 17 | 37 | 108 | 13 | 17 | 138 |
| Total | 66 * | 46 | 112 | 638 | 128 | 164 | 930 |

* Includes 26 seedlings.

(d) Capsid Control

Hand painting of those cacao seedlings still within reach by this method was carried out during August. 7.45 gallons of DDT concentrate were used on 125,000 seedlings. The spray-painting technique was used on other seedlings. All applications of DDT were accompanied by

pruning .../

pruning of dead and damaged twigs. Very little capsid damage is now apparent on the seedling areas.

It was reported in the previous Quarterly Report that areas of badly attacked mature trees on the Old Station and at Akwadum had been coppiced. Excellent chupon growth has been produced with up to six shoots on some stumps. No capsid attack has yet been observed during fortnightly inspections.

(e) Frequency of picking experiments

A group of trees on one of the better cacao areas of the Square Mile has been selected for an experiment, commenced during this quarter, to determine the different effects on yield of pods and beans and on percentage pod discards of 3, 6, 12 and 24 day intervals between pickings. The experiment is duplicated at Kukua substation where the initial incidence of pod disease was very much lower.

SUBSTATIONS

An appreciable crop is offering on all substations except Akwadum. Routine work has included picking, shade thinning (rain trees and avocado pear trees at Adonkwanta, oil palm pruning at Nankese) and the removal of dead and damaged twigs and shoots.

Extreme drought conditions have pertained at Nankese during August and September. Cacao on the sub-marginal areas adjacent to rock outcrops and extending in some cases twenty to thirty yards down the slopes is being defoliated and some deaths have been reported.

The incidence of Swollen Shoot is shown in the following table :-

TABLE II

| Station | Number of trees |
|---|---|
| Adonkwanta | 1 |
| Akwadum | 1 |
| Nankese | Nil |
| Kukua | 3 |
| Koransang | Nil |

METEOROLOGY .../

METEOROLOGY

Rainfall for all stations is given below :-

TABLE III

| Station | Rainfall in inches | | | | Wet days | | | |
|---|---|---|---|---|---|---|---|---|
| | July | August | Sept. | Total | July | August | Sept. | Total |
| Tafo 1954 | 0.95 | 1.09 | 8.01 | 10.5 | 13 | 14 | 18 | 45 |
| " (16-yr. mean) | 5.67 | 2.72 | 6.13 | 14.52 | 13.6 | 12.8 | 14.1 | 40.5 |
| Adonkwanta | .52 | .77 | 9.27 | 10.56 | 3 | 4 | 11 | 18 |
| Akwadum | .65 | .53 | 9.04 | 10.22 | 9 | 5 | 14 | 28 |
| Nankese | 1.47 | .91 | 5.00 | 7.38 | 4 | 3 | 6 | 13 |
| Kukua | .94 | .75 | 3.76 | 5.45 | 3 | 4 | 10 | 17 |
| Koransang | 1.40 | .71 | 7.11 | 7.11 | 6 | 3 | 11 | 20 |

DIVISION OF ENTOMOLOGY

MEALYBUG STUDIES

Population Studies

The experiment to compare populations of mealybugs, predators and parasites in association with attendant ants on cacao in bush and in well-cultivated areas is almost completed. No definite conclusions may be drawn from the survey until the full data for 1954 have been obtained.

Cultural-biological control of mealybugs

In addition to the study of cultural conditions on mealybug populations, a new line of work was commenced to study the possible uses of the ant Oecophylla longinoda and the scale Stictococcus sjostedti in biological control. Oecophylla is positively associated with Stictococcus, negatively associated with mealybug-attending ants and only rarely found in association with mealybugs. A preliminary search was started for trees providing the most favourable nesting site for this ant. Distribution maps of the ants in a block of 1,000 cacao trees growing in association with coffee and oil palm were made in September. Preliminary observations suggest an association of the ant with the edges of plots and breaks in the cacao canopy where sunlight penetrates to the ground litter and cacao trunks. Further studies are in progress to investigate the conditions influencing the abundance of Stictococcus.

Aerial Migration Studies

An experiment to study the aerial movement of mealybugs by trapping on 3,000 cacao seedlings and 180 sticky traps on the WACRI reservoir commenced in August. During the

first .../

first six weeks of the experiment 45 mealybugs were recorded on the seedlings including representatives of all developmental stages, with an abundance of the species F.virgata. Captures on the sticky traps have been disappointingly few.

An experiment to study the aerial movement of mealybugs within a block of cacao commenced in September. Sticky traps were erected at eight sites in closed and open canopies from 2 to 30 feet above the ground. The position of capture on the trap is recorded as an indication of the direction of movement. No results are yet available.

An experiment commenced at the end of the quarter to study the possible effect of forest trees on the deposition of mealybugs being carried by wind. One hundred traps, each of 20 seedlings, have been erected around an isolated Ceiba pentandra. A further experiment is in preparation to study similar effects in an area containing a variety of forest tree species. In this experiment traps will consist of 10,000 cacao seedlings.

Canopy Migration Studies

Preparations have been made to study the movement of mealybugs in the cacao canopy. Traps will consist of seedlings interlocking with the canopy of heavily infested trees.

Radioactivity laboratory

Progress has been made with the radiophysics laboratory and it is hoped to start preliminary experiments with radioactive insects in the next quarter.

CAPSID INVESTIGATIONS

Routine Collections

The Routine Collections carried out in Tafo area have indicated a sharp increase in capsid population during the past three months. This has been due to the increased breeding activity of both species on the vegetative parts of trees and on seedlings. It is interesting to note that a similar increase has not been observed on pods.

Ecological Investigations

Field observations: The observations on the effect of environmental factors on capsid population has continued. The arrival of a consignment of meteorological instruments has enabled these observations to be carried out in a further series of plots.

Laboratory work: Experiments have been commenced to investigate the behaviour of capsids under conditions of controlled temperature and humidity.

Capsid Control : Dusting and Pruning Experiments

The treatments in the Dusting and Pruning Experiment commenced during the last quarter on WACRI Square Mile have continued.

In the experiment of similar type at Akwadum the removal of chupons has been carried out in those plots which are under that treatment. As the stand is only two years old many of the trees have only recently jorquetted and it

has .../

has been decided therefore to postpone the dusting treatment until the beginning of next year. Handpainting with DDT emulsion will continue throughout the experimental area until then.

A Costing Trial of the Dusting and Pruning method of capsid control is continuing in a plot of 2 acres of West African Amelonado cacao situated in the Old Station. The removal of developing chupons and damaged shoots, and inspection for recent capsid damage followed by localised insecticidal dust application are carried out at fortnightly intervals. The labour requirements for the past four months have been as follows :-

| | |
|---|---|
| Inspection, removal of chupons and damaged shoots ... ... ... ... | 2½ man days/acre/month |
| Dusting .. ... ... ... | 1 man hour/acre/month |
| Quantity of dust used (5% DDT) | 1 lb/acre/month. |

The large scale insecticide trial on bearing cocoa at Nankese Sub-station continues. The area has suffered acutely from drought during the quarter and in consequence a great deal of defoliation was evident in September. The rains broke during the last week of that month and very heavy flushing is now expected.

The experiment to assess the effect of overall spraying with DDT emulsion on cacao continues. To date surprisingly little damage has occurred even on tender flushes.

## BIOLOGICAL CONTROL OF MEALYBUGS

### Introductions

In addition to Anagyrus pseudococci, a new introduced parasite has been arriving from California since July. This has been designated "M" by the Commonwealth Institute of Biological Control and to date no information has been received concerning its identity. It has so far failed to reproduce in any of the mealybugs against which it has been tested.

### Releases

A total of 60,095 parasites, made up as follows, has been liberated in the Old Station during the quarter :-

36,170 Pseudaphycus angelicus

20,480 P. mundus

3,445 Anagyrus pseudococci

### Recoveries

Pseudococcus njalensis collections from the Koransang and Bunso release areas yielded a single adult each of a Pseudaphycus sp. probably mundus during the present quarter. P. mundus was never released at Koransang and its presence there may be due to contamination in the insectary at Tafo.

No recoveries have been made from the Old Station.

Systemic .../

Systemic Insecticides

The Atukrom experimental plot continues to be inspected at monthly intervals. Mealybug counts are made on all diseased trees cut out. The number of mealybugs found has been very small.

An experiment has been started in conjunction with Messrs. Pest Control Ltd., to confirm, using the trunk injection method of application, that second or subsequent doses of Hanane are in fact absorbed by the tree. With the cacao available for this experiment, difficulty has been experienced with the natural re-establishment of mealybugs after initial treatment and resort has been made to artificial re-infestation.

## DIVISION OF PLANT PATHOLOGY

### VIRUS RESEARCH

Host Range Studies

The survey of Adansonia digitata L. for virus infection has revealed two more naturally infected trees on the Accra Plains, which brings the total to four. Isolated trees of this species have been found in many villages in the cacao areas of the Eastern Province, having apparently been planted by the villagers for food and medicinal purposes. No infections have yet been observed in these isolated trees. A survey has also been made in the Guinea Savannah-Woodland along the Ashanti - Northern Territories border. The results of tests for infection on specimens collected in this area are awaited.

Material has also been collected from Ceiba pentandra Gaertn., Sterculia tragacantha Lindl. and Sterculia rhinopetala K. Schum. growing in the Tafo area, and tested for natural virus infection.

Resistance to the New Juaben Strain of Swollen Shoot Virus

In earlier tests at W.A.C.R.I. certain Upper Amazon cacao material, particularly that of Nanay parentage, showed some resistance to infection with the New Juaben strain by vectors, this resistance being associated with tolerance. During recent studies on virus multiplication, in which several Upper Amazon types were used, it was noticed that the Iquitos type was difficult to infect. Consequently, during the last three months, Iquitos-type pods derived from hand-pollinations have been supplied by the Plant Breeders for testing

Each bean from the first nine pods has been dissected and colonized for one day with 40 infective "crawlers" of Pseudococcus njalensis Laing, prior to planting. Similarly treated Amelonado beans were planted along with each batch of Iquitos beans, as controls. Seedlings from the first five pods have shown between 33 and 89% recognizable infection so far, the symptoms on many of the plants being mild compared with those of the controls, all of which were infected. As one manifestation of tolerance may be a lengthened incubation period the above figures cannot at present be interpreted as indicating resistance to infection in a proportion of the Iquitos seedlings; but all symptomless plants will shortly be "back-tested" for the presence of virus, using mealybugs.

Plants .../

Plants that prove virus-free will be colonized a second time with infective vectors. Any that still remain uninfected after this can be considered highly resistant to the New Juaben strain and worth propagating for comprehensive field trials. Tolerance, unless associated with a very high degree of resistance, is not considered a desirable characteristic.

Virus-Vector Relations

The first experiment on the effect of different source-feeding times on infection rate (see previous Quarterly Report) is now complete. Pre-starved young adults of Pseudococcus njalensis were used as vectors and the apical tissues of young Amelonado seedlings infected with the New Juaben strain as sources of virus. Dissected Amelonado beans were used as test plants, and the mealybugs were transferred to them at the rate of two per bean immediately after completing the appropriate source-feeding period.

The results are summarized below :-

| Source feeding time (hours) | 2 | 4 | 8 | 16 | 32 | 64 |
|---|---|---|---|---|---|---|
| Infection rate (% of 60 plants) | 0 | 8 | 42 | 65 | 53 | 42 |

It appears that the infection rate rises to a peak and then falls off. A statistical examination of the data suggests that a maximum infection rate is to be expected for a source-feeding period somewhere between 16 and 32 hours. This will be further investigated. Posnette and Robertson (Ann. appl. Biol. 37, 241, 1950) obtained evidence of a reduction in the infectivity of pre-starved vectors after source feeding in excess of 10 hours; but they used leaves infected with the Mampong strain as a source of virus and nymphs of P. njalensis, subjected to 12 hours preliminary starving, as vectors.

An experiment has been started to find out the effect of different preliminary starving periods on infection rate. Young adult mealybugs (P. njalensis) that appeared to be feeding on healthy material were removed and starved for 0, 3, 6, 12, 24 and 48 hours respectively before placing on separate plants for a 16-hour source-feeding period. After this, they were transferred from each source plant to ten test beans at the rate of one per bean. This procedure was repeated six times over a 15-day period, each source plant being assigned in turn to each of the six starving treatments. Final results are not yet available but there seem to be no real differences in infection rate between the treatments. The experiment will be repeated using a shorter source-feeding time.

There seemed to be some doubt, from earlier reports, whether Pseudococcus concavocerarii James is a vector of swollen shoot disease or not. In recent experiments this species has transmitted the New Juaben strain to two out of fifteen test plants (dissected beans), using five insects (adults and nymphs) per bean.

Strains of the Swollen Shoot Virus Complex

Studies on the inter-relationships of West African cacao virus strains are continuing, and an investigation

has .../

has been started, in the insectary, into the breakdown of mild-strain protection in the New Juaben complex.

An outbreak has been inspected at Nkoranza in the Wenchi Division of Ashanti, which is reported by the Department of Agriculture to be the most northerly one discovered so far. The symptoms showed very little resemblance to those of other Gold Coast strains, and this Nkoranza strain may be quite distinct. Leaves and budding material were collected for transmission tests in the laboratory.

Infections have been obtained in young plants budded with material collected in March from an outbreak near the village of Goviepe Todzi in British Mandated Togoland. The symptoms seem to be identical with those of the Kpeve strain, which was first discovered 14 years ago on the Kpeve Agricultural Station, about three miles away. One of the plants budded at the same time with material from the mild-strain outbreak at Peki Tsame Agato has produced a single swelling. Leaf symptoms have never been observed with this strain.

Chemical Tests for Swollen Shoot Disease Diagnosis

The survey of the WACRI Old Station cacao using the test described by Usher and Tinsley (Nature, 174, 87, 1954) has continued. To date 15 quarter-acre blocks (4025 trees) have been tested. More symptomless trees have given a positive reaction in blocks where active virus outbreaks have been recorded (by visual inspection) than in those without recorded outbreaks; when not associated with a known outbreak such trees occur mainly in groups. Although these observations indicate that symptomless trees which have given a positive reaction to the test may be infected, so far only 1.3% of them have been visually diagnosed. On the other hand, symptomless leaf-samples collected from 81 trees on the Old Station known to be infected have all given a positive reaction. A full investigation into the limits of accuracy of the test is being started. This will involve comparing the results it gives with those from "back-tests" on the same trees.

A somewhat similar chemical test for virus infection described by Ninomiya and Hino (Bull. Fac. Agric. Yamaguti Univ. 2, 13, 1951: Abs. in Rev. appl. Mycol. 32, 581, 1953) is being tried with cacao. This involves heating leaf discs of the material in a test-tube with 1 to 2N potassium hydroxide and then with 0.5% copper sulphate solution added. Initial experiments have also been made using a method described by Cornuet (C.R. Soc. Biol., Paris, 237, 1364, 1953). This test estimates the ammonium ion in ammonium glutamate formed by heating an alcoholic extract of the leaves at pH7. As it seems to depend on an entirely different chemical reaction from that of the W.A.C.R.I. test, the method may prove applicable to other cacao varieties besides Amelonado, a possibility which will be investigated when infected non-Amelonado material becomes available.

BLACK POD DISEASE

Fungicide Control: Trial I

Harvesting and spraying treatments have been continued during the quarter. Some of the results from the harvesting treatments applied during the 1953-54 season have been analysed. The total pods (healthy and diseased) from the weekly harvested plots exceeded those from the monthly harvested plots by 37.7%. The difference may be partially due to an increase in fruit setting as a result of frequent removal of immature diseased

pods .../

pods from the weekly harvested trees. The Division of Agronomy has begun a "Frequency of Harvesting Experiment" to gain more information on this point, and the final figures from the control plots in Trial II for the present season may also help to elucidate it. The two harvesting treatments also differed in the totals of undamaged pods, discarded pods, 'Black-Pods', and discarded 'Black-Pods'; also in the wet-weights of good beans from both healthy and diseased pods. Some of these differences may merely reflect the difference in total pods for the two treatments; others may arise from better recovery of good beans from incompletely diseased pods and/or reduced pod-disease incidence, resulting from more frequent harvesting. This will not be clear until the analyses are complete.

The results after completing spraying and harvesting treatments for this quarter are briefly summarized below:-

| Treatment | Pods per tree | | | |
|---|---|---|---|---|
| | Total | Damaged | 'Black-Pods' | Otherwise Damaged |
| Control (Unsprayed) | 28.95 | 17.34 | 10.25 | 7.09 |
| 'Carbide-Bordeaux' | 24.73 | 11.67 | 6.62 | 5.05 |
| Bordeaux Mixture | 32.55 | 17.08 | 9.82 | 7.26 |
| 'Perenox' | 24.06 | 12.32 | 7.26 | 5.06 |

So far no treatment seems to have given any major increase in good pods, though there appears to have been a slightly better recovery of good wet beans from weekly harvested plots compared with those harvested every month.

Fungicide Control: Trial II

Similar figures to those for Trial I above are given below :-

| Treatment | Pods per tree | | | |
|---|---|---|---|---|
| | Total | Damaged | 'Black-Pods' | Otherwise Damaged |
| Control (Unsprayed) | 12.31 | 6.69 | 4.49 | 2.20 |
| 'Perenox' | 11.57 | 6.40 | 4.45 | 1.95 |
| 'Blitox' | 9.84 | 5.65 | 4.64 | 1.01 |

Again, no treatment appears to have reduced the number of 'Black-Pods' or total damaged pods, though it should be remembered that spraying, in both Trials, has been in progress for only 4 months.

During the period, there was a seasonal decrease of 'Black-Pod' over the whole experiment from 73.3% in June to 19.1% in September, and an increase in undamaged pods

from .../

from 6.0% to 63.5%. This suggests that the incidence of the disease may be influenced by other factors besides rainfall.

Air-borne Dissemination of the Disease

An experiment to investigate the air-borne spread of spores of Phytophthora palmivora Butl. has been laid out on the 1st Progeny Trial Area at W.A.C.R.I. A suction-type spore-trap is being operated for twenty-four hours each week at the centre of a circular block of 89 trees in the middle of the area. All pods on these 89 trees are artificially inoculated with 'Black-Pod' disease when they reach a length of about 4 inches. A further 176 trees selected at random over the rest of the 1st P.T.A. are harvested weekly, pod-disease records being kept for each.

Training of Department of Agriculture Personnel

During the quarter, fifty Field Assistant Propagators from Department of Agriculture Cacao Stations have been instructed in the recognition of pod diseases. The main object was to train them to keep accurate records of 'Black-Pod' disease on their Stations.

## DIVISION OF BOTANY

### VEGETATIVE PROPAGATION

Seasonal variation in rooting behaviour of single leaf cuttings

The results of this experiment have now been analysed, in which the rooting performances of three clones rated as having "good", "medium" and "poor" rooting behaviour were compared over a period of twelve months. In addition two petiole treatments were compared with the control. The results can be summarised as follows :-

(1) The season of the year in which cuttings are taken affects the rooting behaviour markedly.

(2) The observed differences between clones are maintained independently of seasonal variations.

(3) There is a strong indication of an autonomous rhythm in rooting behaviour.

(4) There is an apparent deterioration in rooting behaviour of cuttings, derived from the same source, with time.

(5) There is a positive correlation, in the two poorer rooting types, between the number of cuttings rooted and the number of roots on each cutting.

(6) The removal of a ring of cortical tissue increased the number of cuttings rooted by the "poor rooter" by about 45% and the number of roots by 30-40%. The treatment was without effect on the two better rooting clones.

Stock-Scion influence in budded plants

In conjunction with the Plant Breeder clones have been established of trees showing marked characters of habit

such .../

such as dwarfness, extreme vigour etc. Chupon buds of a single high-yielding clone will be grafted on the rooted cuttings to test whether the habit of the scion is affected, and to what extent, by the stock.

Training of clonal plants

Establishment of rooted cuttings in the plot intended for experiments in controlled growth has been poor, and the plants are too immature to be pruned.

Routine Propagation

There is a heavy demand for clonal material of cacao, and other species, which is tending to strain the present capacity of the propagating unit.

TISSUE CULTURE

Attempts are being made to induce bud formation on cacao explants by means of adenine sulphate, incorporated in the culture medium.

GROWTH SUBSTANCES

Work has continued intensively on the isolation, by paper chromatography and bioassay, of growth substances in cacao seeds and seedlings.

FLUSHING BEHAVIOUR IN CLONAL PLANTS

The plants reported previously as receiving continuous light, have, after initial defoliation, shown a marked proliferation of dormant buds and appear very healthy. Those receiving diffuse daylight for only eight hours have also defoliated but there has been very little bud proliferation.

Small experiments have been started to test the effect of leaf-removal on bud proliferation.

PLANT BREEDING

Established trials

The bulk of the crop has been harvested earlier than usual. By the end of the quarter 45% of the previous years' crop had been harvested from the 2nd P.T.A. and 55% from the Introductions Area. It is still uncertain whether last year's total of pods will be reached in these areas.

The Clonal Trials are giving an increased yield. The 1st Clonal Trial has so far yielded 90% of the previous best total and the 2nd Clonal 70% of the previous best.

Swollen Shoot Control

There has been a decrease in the incidence of swollen shoot during the quarter; it is possible that flushing has been less and that consequently the symptoms of C.S.S.V. have been more difficult to detect.

Cytogenetics

The study of the tetraploids of cacao produced

last .../

last October with the drug colchicine has continued. It has been shown that stomatal frequency per unit area and stomatal size are affected by tetraploidy of the epidermis.

Beans resulting from the cross T. cacao x T. angustifolia have been germinated and treated with colchicine. It is too early to estimate the effect of the drug on these plants.

Poor flowering during the quarter has slowed up the incompatibility and pollination studies.

Department of Agriculture Plots, Gold Coast

The nine Series I Variety Trials run in co-operation with the Department of Agriculture are all well established. So far the establishment of the first Series II trial at Bunso has been good. The Series I trials were designed to compare the performance of distinct types of cocoa (West African Amelonado, Local Hybrids, and three types of Upper Amazon) on different soils and under different climatic conditions. The Series II trials are designed to test the new varieties resulting from the breeding programme. Sites have now been chosen at Foso and Asikuma and it is hoped to approve seven further sites during next quarter.

In addition to the clone collections at Juaso and Poanu one has now been established at Bunso. The Department are being advised as to which clones should be multiplied rapidly.

Despatch of Material

Over 3,000 pods of the ten approved Upper Amazon types have been sent to Nigeria during the quarter.

Small consignments of selected material have been sent to Liberia, Belgium (for later shipment to Belgian Congo) and French Ivory Coast.

PLANT PHYSIOLOGY

Root Studies

There is no difference in the first six months growth of cacao seedlings grown in conjunction with different species of forest tree seedlings. None of the cacao root systems showed any signs of grafting with the forest tree roots, and in no case were the cacao roots stunted as compared with controls. The forest seedlings used were species of Cola, Bombax, Ceiba and Sterculia.

Preliminary results support the idea of root flushes in mature trees alternating with leaf flushes. Investigations are proceeding into the factors affecting root flushes.

Cherelle Wilt

The rate of pod growth is correlated with maximum temperature. This was found as a result of daily measurements of pods of different sizes over several weeks. As would be expected from this it was found that pods grew much more rapidly during the warm months of April and May than during the colder months of July and August.

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As a result of the study of a large number of hand-pollinated pods two types of wilt have been observed. The first one occurs from the time of fruit set till the pod is 7-8 cm. long, reaching a peak at about 5-6 cm. The second period of wilt occurs on pods of 8-11 cm. long and is not as important as the first one since fewer pods are concerned.

In pods which wilt in this second period, stalk development ceases 10-20 days before wilting is evident and the embryos are proportionately larger than in healthy pods of similar size.

Pods were sprayed with 50 ppm. indole-acetic acid in an attempt to reduce wilt. Although the spray was found on analysis to have penetrated the pod stalk, there was no effect on wilt.

The final results in the experiment where flushing was prevented throughout the season shows an increase in yield which just fails to be significant. This experiment will be repeated on a larger scale.

## DIVISION OF SOIL SCIENCE & CHEMISTRY

Work in the Chemistry Section since the Chemist's resignation has been confined to a few routine analyses for Botany Division.

The Soil Chemist returned from leave on August 8th but attended the Fifth International Congress of Soil Science in the Belgian Congo until September 9th. In what remained of the quarter, routine fertilizer applications were made on the existing field trials and no new work was started.

## IBADAN SUB-STATION

### PATHOLOGY DIVISION

#### Offa Igbo Observation Plot

Symptom recording has continued at the Offa Igbo Observation Plot and the latest list of results is given in Table I.

TABLE I .../

TABLE I

| Observation | Total Number of Trees | Number Infected | New Infection |
|---|---|---|---|
| October | 290 | 30 | 13 |
| November | 290 | 39 | 9 |
| December | 290 | 50 | 11 |
| January | 287 | 55 | 5 |
| February | 287 | 64 | 9 |
| March | 287 | 78 | 14 |
| April | 286 | 95 | 17 |
| May | 286 | 109 | 14 |
| June | 275 | 122 | 13 |
| July | 274 | 131 | 9 |
| August | 274 | 135 | 4 |

The number of seedlings showing symptoms after grafting with material from the Offa Igbo trees has increased to 44. Successful grafts have now been made to seedlings from all trees in the plot.

Records on an individual tree basis are now being made on the yield of all trees on the Offa Igbo and Koroboto Observation plots.

Chemical Diagnosis of C.S.S.V. Infection

Using the colour test as described by Tinsley and Usher (Nature, 174, P.87 1954) an examination was made of 127 trees in the Offa Igbo Plot.

Comparison with symptom observations revealed apparently anomalous results and a complete report on this work has been sent to the Senior Pathologist at Tafo and further work using the test has been stopped pending his advice.

Coppicing Experiments

The coppicing experiments in association with cacao survey have continued, and in addition to the outbreak at I.N.A. farm referred to in the previous quarterly report, four other outbreak areas have been coppiced.

A full report has been prepared on the regeneration of cacao by coppicing and this is to be distributed.

At the I.N.A. farm observations indicate that regeneration is related to girth and to coppicing height (Table II).

TABLE II .../

TABLE II

SUCCESS OF REGENERATION IN RELATION TO GIRTH AND COPPICING HEIGHT: I.N.A. CACAO FARM 1954

| Girth Category | Coppicing Height | | | Total | Percentage Successful |
|---|---|---|---|---|---|
| | From 12" | From 9" | From 6" | | |
| 1"- 4" | 9/10 | 3/3 | 3/4 | 15/17 | 88 |
| 5"- 8" | 11/12 | 11/15 | 11/12 | 33/38 | 87 |
| 9"-12" | 14/15 | 15/18 | 11/15 | 40/38 | 84 |
| 13"-16" | 12/13 | 13/16 | 6/14 | 31/43 | 72 |
| 17"-20" | 14/21 | 19/24 | 11/26 | 44/71 | 62 |
| 21"-24" | 12/19 | 9/15 | 7/21 | 28/55 | 51 |
| Total | 72/90 | 70/90 | 49/92 | 191/272 | 70 |
| % Successful | 80 | 78 | 53 | 70 | |

(The fractions indicate the number successful out of the total in a particular category).

Two acres of mature cacao have been coppiced and the chupon pruning technique used in the Belgian Congo is to be applied to the growth from the stumps.

Incubation Period of C.S.S.V.

As a preliminary to the work to be done at Agodi, experiments have been started at I.N.A. farm to investigate the length of time elapsing between the infection of trees using grafts or mealybugs, and the appearance of symptoms and development of infectivity.

Host Range Investigations

Shortage of mealybugs continues to limit this work. Attempts are being made to find natural infection in Adansonia digitata trees in the Oyo and Iwo areas.

Observations on Infected Seedlings

Detailed symptom observations are being made on 10 groups of seedlings, each group of which is infected with one of 10 isolates of C.S.S.V. The growth of these seedlings is also being compared with that of healthy controls.

Inhibition Studies

A T.M.V. culture has been purified and a local Phaseolus sp. has been found which produces discrete local lesions under present conditions.

ENTOMOLOGY DIVISION

Natural Enemies of Mealybugs

Four species of hymenopterous parasites, not previously represented in the W.A.C.R.I collection, have

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been reared from mealybugs during the quarter, and a fifth from larvae of the predacious coccinellid, Platynaspis higginsi Crotch. Three other species of Encyrtidae have been reared from mealybug hosts which they were not previously known to attack.

A full report on the progress of the survey of parasites of Nigerian mealybugs up to the middle of July has been prepared.

Mealybug Population Studies

Mealybugs have been collected from cacao farms in the Ondo, Owo and Ekiti Divisions of Ondo Province, in the vicinity of Ilaro, Papalanto and Abeokuta in Abeokuta Province, and at Ina, Agodi, Ikire, Adifa, Odo-Ona, Ilesha and Moor Plantation in the Ibadan Province.

Twenty-four trees at I.N.A. were examined from ground level and all mealybug colonies collected. The trees were then felled and all colonies on the rest of the tree were collected. The data thus obtained indicate that it is not possible to estimate, with any accuracy, the total mealybug population of a tree by counting mealybugs visible from ground level. It was further found that certain species, principally Pseudococcus concavocerarii and Ferrisiana virgata, accounted for a greater proportion of the total mealybugs in ground level samples than they did of the total for the whole tree, and that the percentage of nymphs tended to be lower in these samples.

Mealybug Cultures

Potato sprouts bearing the parasite-free cultures of mealybugs referred to in the Quarterly Report for January to March 1954 were severely attacked by a fungal or bacterial disease in June which resulted in the total loss of all cultures. Supplies of suitable potatoes have not since been available and culturing has been confined to attempts to re-establish parasite free stocks on cacao seedlings, but losses due to attacks of natural enemies, principally cecidomyiid predators, have been very heavy and little progress has so far been possible.

Root Infesting Mealybugs

A small culture of Geococcus coffeae has been established on the roots of infected cacao seedlings planted in root observation boxes and adults and nymphs have been transferred from this culture to roots of healthy seedlings, but results of this virus transmission test are not yet available. In an attempt to culture Dysmicoccus sp. nr. brevipes under similar conditions ovisacs were produced by the pre-gravid adult bugs introduced but crawlers failed to survive.

Preliminary trials have been made in the use of a Berlese funnel as a possible method of collecting root infecting mealybugs. Soil containing G. coffeae and D. brevipes from the roots of Canna indica was used, and it was found that recoveries of mealybugs were greater when the soil was allowed to dry slowly for ten days than if heat was applied, when recoveries were made on the first four days only. In both treatments the recovery of G. coffeae was better than that of D. brevipes. As G. coffeae is an unusual looking mealybug,

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with morphological characters which probably enable both adults and nymphs to move through soil more readily than could normally shaped pseudococcids, it would appear that this may not prove to be an entirely satisfactory method of collecting mealybugs from cacao roots, though it may well be useful as a method of obtaining G. coffeae for vector studies. These trials are to be continued.

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